SECTION 556
STEEL STRUCTURES

556.01 DESCRIPTION. This work is the furnishing, fabricating, painting, and erecting of steel structures and the steel structure portions of composite structures.

The Department has calculated the contract quantities using the following:

Material	Weight per foot (meter)
Malleable Iron	470 lbs (700 kg/m)
Wrought Iron	487 lbs (725 kg/m)
Steel, rolled, cast copper bearing, silicon nickel, and stainless	490 lbs (729 kg/m)

The weights of rolled shapes and plates up to and including 36-inches (915 mm) in width are computed based on their nominal weights and dimensions as shown on the shop drawings. One-half of the allowed percentage of overrun in weight as tabulated in ASTM A 6 will be added to the nominal weights of plates exceeding 36-inches (915 mm) in width. The weight is computed on the basis of rectangular dimensions for all plates and overall lengths for all structural shapes with no deductions for copes, slips, sheared edges, punching, borings, milling, or planing. When parts can be economically cut in multiples from materials of larger dimension, the calculated weight is that of the material from which the parts are cut.

Bolts, nuts, and washer weights are the calculated weight in the AISC Manual of Steel Construction.

A 0.4% multiplier may be specified in the Contract and added to the computed weight of metals for shop paint.

Weld metal weight is computed on the theoretical volume of the weld dimensions. A 50% allowance is added to the weight for overrun.

556.02 MATERIALS. Furnish materials meeting the following Subsections:

Structural Steel	711.02
Structural Steel Tubing	711.03
Pins and Rollers	711.04
Welding Electrodes	711.05
High Tensile Strength Bolts	711.06
Bolts and Nuts	711.07
Galvanized Metal	711.08
Welded Stud Shear Connectors	711.09
Castings	711.12
Fiber-Reinforced Pads for Bearing Plates	711.16
Bearing Assembly Anchor Bolts for Bridges	711.13
Elastomeric Bearing Devices	711.14
Compression Joint Seals	711.15

556.03 CONSTRUCTION REQUIREMENTS.

556.03.1 Pre-qualification. Metal fabricators must be pre-qualified under the AISC Quality Certification Program. Registration and certification of the plant or shop under the AISC program, Category I, II, or III, and submission of a valid certificate to the Bridge Engineer, MDT, 2701 Prospect Avenue, Helena, MT, 59620-1001, is required. Furnish an annual endorsed copy for continued qualification.

Use only fabricators having a Category III certification to fabricate the following:

1. Fracture critical members and attachments (Certified Fractures Critical);
2. Main members, except for rolled beams;
3. Welded floorbeams;
4. Cross frames and diaphragms for curved bridges.

Use fabricators having a Category I, II, or III certification to fabricate the following:

1. Modular Expansion joints;
2. Welded bearings;
3. Steel grid flooring;
4. Overhead, Truss, and cantilever sign structures;
5. Lighting poles and anchor bases.

Materials not requiring shop fabrication or shop welding, such as plates and shapes for strengthening existing bridges and manufactured items are accepted by certification.

556.03.2 Fabrication Drawings. Submit 5 copies of the fabrication drawings to the Project Manager for review. Include on the drawings complete details, dimensions, size of material, welding procedures, and other information necessary for the complete fabrication and erection of the work.

Check and approve fabrication drawings before submitting them to the Project Manager. Assure the Contractor's approval stamp and signature is on each drawing.

The Project Manager must review the Drawings before fabrication begins. The Department has 20 working days to review and return the fabrication drawings. The Contract time will be extended day for day for any delay beyond the 20 day review period.

Furnish 3 or more approved copies of the drawings after the Project Manager's review. Furnish all fabrication drawings on 22 X 36-inches (A1 paper) with a 1 ½-inch (46 mm) margin on the left side and a ½-inch (43 mm) margin on the other 3 sides. Once the work is completed, provide the original tracings, if required, to the Project Manager.

Changes to the plans or substitutions of sections requested by the Contractor regarding plate size, splice location, details of appurtenances, or details of welds cannot decrease the dimensions or section properties of the member or increase the weight of the member.

Submit all requests for changes to the Project manager for review and approval. All approved changes are at the Contractor's expense, including any additional freight and handling charges. The approved changes will be by change order, and include any cost savings.

556.03.3 Mill and Shop Inspection.

A. **Inspection of Work.** Do not begin manufacturing or shop fabrication until the Departments inspector has inspected the shop.

B. **Facilities for Inspection.** Furnish facilities for inspecting the material and workmanship in the mill and shop. Allow the Inspector free access to the work at all times.

C. **Inspector's Authority.** The Inspector may reject material or work not meeting the specifications. In case of dispute, the Contractor may appeal the inspector's decision to the Project Manager.

D. **Mill Test Reports.** Furnish the Project Manager a complete certified mill test report showing chemical analysis and physical tests for each heat of steel for all members. Identify each piece of steel with a mark number on the mill test report.

E. **Facilities for Testing.** Furnish, at Contractor expense, test specimens, labor, testing machines, and tools to make the specimens and tests.

F. **Rejections.** Material or finished members accepted by the Inspector may be rejected if the material is subsequently found defective. Replace or repair rejected material at Contractor expense.

556.03.4 Storage and Identification of Materials. Store structural steel meeting Subsection 556.03.17 requirements.

Mark alloy and high-strength steels as required by Article 11.4.1 of the AASHTO Standard Specifications for Highway Bridges. Mark material required to meet a Charpy requirement for identification.

556.03.5 Workmanship and Finish. Round all edges of primary members corners to a 1/16-inch (2 mm) radius.

Make all surfaces and edges smooth, uniform, and free from fins, tears, and cracks.

Shear, flame cut, and chip neatly and accurately. Neatly finish all exposed portions of the work.

Straighten rolled material before lay out or working. Do not injure the metal when straightening. The maximum temperature of the steel cannot exceed 1000 °F (537 °C) unless approved. Perform heat straightening of AASHTO M 270 Gr. 100/100w (ASTM A 709 Gr 100/100w) or ASTM A 517 steel only under controlled procedures with the heat application approved by the Project Manager. Material with sharp kinks and bends will be rejected.

Lay out and cut plates and splice plates for flanges and webs with the direction of rolling parallel to the longitudinal axis of the girder. Show on the shop drawings the direction of rolling for these plates.

Curve rolled beams and welded girders meeting Articles 11.4.12.2 and 11.4.7 of the AASHTO Standard Specifications for Highway Bridges.

556.03.6 Finishing and Shaping. Finish members true to line, free from twists, bends, and open joints. Camber girders as shown on the plans.

A. **Edge Planing.** Plane sheared plate edges exceeding 5/8-inch (16 mm) in thickness and carrying stress to 1/4-inch (5 mm). Fillet re-entrant cuts before cutting.

B. Facing of Bearing Surfaces. For bearing, base plates and other bearing surfaces in contact with other members or with concrete, meet the surface-roughness requirements of Table 556-1.

TABLE 556-1
SURFACE-ROUGHNESS REQUIREMENTS*

Steel slabs	ANSI 2,000 (50 μm)
Heavy plates in contact in shoes to be welded	ANSI 1,000 (25 μm)
Milled ends of compression members, stiffeners, and fillers	AMS500 (12.5 μm)
Bridge rollers and rockers	ANSI 250 (6.3 μm)
Pins and pin holes	ANSI 125 (3.2 μm)
Sliding bearings	ANSI 125 (3.2 μm)

*As defined in ANSI B Y 14.36-1978 Surface Roughness, Waviness, and Lay, Part I

Stress relieve shoes meeting AWS specifications after all welding and before pin holes are drilled or curved bearing surfaces are finished.

C. Abutting Joints. Face and bring to an even bearing, abutting joints in compression members, girder flanges, and tension members, if specified. Joints not faced must have an opening not exceeding 1/4-inch (5 mm).

D. End Connection Angles. Build floor beams, stringers, and girders with end connection angles to exact length back-to-back of connection angles. Assure the finished thickness of the angles is at least that shown on the plans if end connections are faced.

E. Web Plates. Do not exceed a 3/8-inch (10 mm) clearance at web splices between the ends of the web plates. Do not exceed 1/4-inch (5 mm) clearance at the top and bottom ends of the web splice plates.

F. Bent Plates. Furnish cold-bent, load-carrying, rolled-steel plates meeting the following requirements:

1. Use stock plates that place the bend lines at right angles to the direction of rolling.
2. Bending must not crack the plate. Meet minimum bending radii, measured to the concave face of the metal, as specified in Table 556-2.

TABLE 556-2
MINIMUM BENDING RADII - ROLLED STEEL PLATES

	THICKNESS OF PLATE IN INCHES (MM)				
	Up to ½ (12mm)	Over ½ to 1 (12 mm to 25 mm)	Over 1 to 1½ (25 mm to 38 mm)	Over 1½ to 2½ (38 mm to 63.5 mm)	Over 2½ to 4 (66 mm to 100 mm)
Bending Radii**	2t*	2½t*	3t*	3½t*	4t*

* t = plate thickness
** For all grades of structural steel in this specification.

Hot bend low alloy steel over ½-inch (12 mm) thick for small radii if required.

Springback allowance for AASHTO M 270 Gr. 100/100w (ASTM A 709 Grade 100/100w) and ASTM A 517 steels is about 3 times that for structural carbon steel. When break press forming, use a lower die span at least 16 times the plate thickness.

Hot bend the plates at a temperature not exceeding 1200 °F (649 °C), excluding AASHTO M 270 Grade 100/100w (ASTM A 709 Grade 100/100w) and ASTM A 517 steels if a shorter radius is required. Re-quench the plates and temper following the mill's common practice if AASHTO M 270 Grade 100/100w (ASTM A 709 Grade 100/100w) or ASTM A 517 steel plates to be bent are heated to a temperature exceeding 1125 °F (607 °C). Hot bent plates must meet requirement (1) above.

3. Round the corners of the plate to a radius of 1/16-inch (2 mm) throughout the area to be bent.

G. **Fit of Stiffeners.** Mill or grind end stiffener plates or girder and stiffener angles for use as supports for concentrated loads to provide an even bearing against the flange. Make fillers under stiffeners to fit within 1/4-inch (5 mm) at each end. Welding is permitted in lieu of milling or grinding if noted in the Contract. Welding transversely across the tension flanges of beams or girders is permitted only with the Project Manager's approval.

Horizontal stiffeners must not leave a gap exceeding 2-inches (50 mm) between the vertical stiffeners and the end of the horizontal stiffeners.

H. **Flame Cutting.** Steel or wrought iron may be flame cut, if a smooth surface is produced using a mechanical guide. Perform hand flame cutting only where approved, smoothing the surface by planing, chipping, or grinding. Adjust the cutting flame to prevent cutting beyond the specified lines. Make fillet re-entrant cuts having a minimum radius of ½-inch (10 mm).

Remove flame-cut edges back at least 1/4-inch (5 mm) by milling, chipping, or grinding for silicon steel. Machine flame-cut edges may be used as cut if the edges are softened after cutting by either of the following methods:

1. Heat the cut edge uniformly and progressively to a red heat (1150 °F to 1250 °F) (621 °to 676 ° C) to at least 1/16-inch (2 mm) deep;
2. Using a post-heating torch attached to and following the cutting torch; regulate the tips, gas pressure, speed of travel, and the distance of post-heating torch from kerf to the thickness of the steel.

556.03.7 Pins and Rollers.

A. **General.** Furnish straight, smooth pins and rollers meeting the specified dimensions, free from flaws. Forge and anneal pins and rollers more than 9-inches (225 mm) in diameter. Pins and rollers 9-inches (225 mm) in diameter or less may be forged and annealed or cold-finished carbon-steel shaft.

Gradually cool pins 9-inches (225 mm) in diameter or larger to prevent damage before annealing. Bore a hole 2-inches (50 mm) or larger in diameter the full length along the axis.

B. **Boring Pin holes.** Bore pin holes to the specified diameter at right angles with the axis of the member, and parallel with each other unless otherwise specified. Finish cut the final surface.

Maintain a tolerance of ± 1/32-inch (1 mm) for outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members.

Bore holes in built-up members after the welding is completed.

C. **Pin Clearances.** Meet the following pin hole diameter maximum tolerances:
   1. The pin diameter plus 1/50-inch (0.5 mm) for pins 5-inches (125 mm) or less in diameter;
   2. 1/32-inch (1 mm) for larger pins.

D. **Surface Finish.** Finish surfaces of bridge rollers, rockers, pins and pin holes meeting Subsection 556.03.6(B) requirements.

E. **Pilot and Driving Nuts.** Furnish 2 pilot nuts and 2 driving nuts for each size of pin unless otherwise specified. Pilot and driving nuts are not required when shoes are assembled at the fabrication plant.

F. **Threads.** Use Unified Standard Series UNC - ANSI B1.1, Class 2A threads for external threads, and Class 2B for internal threads, for all imperial dimension bolts and pins for structural steel construction, except for pin end diameters of 1⅜-inches (35 mm) or more which must be 6 threads to the inch (25 mm).

Furnish American Standard Metric Screw Treads - M Profile, ANSI B1.13M-1983 for all metric dimension bolts and pins for structural steel construction. Tolerance is Class 6H/6g. Use a 4 mm pitch for pin end diameters of 35 mm or more.

556.03.8 Bolt Holes.

A. General. Punch or drill all bolts holes.

Members built up with 5 thicknesses or less of metal may be punched 1/16-inch (2 mm) larger than the nominal diameter of the bolt, if the metal thickness does not exceed 3/4-inch (19 mm) for carbon steel or 5/8-inch (16 mm) for alloy steel.

Sub-punch or sub-drill all holes 3/16-inch (5 mm) or smaller for members exceeding 5 thicknesses, where the material is 3/4-inch (19 mm) carbon steel or thicker, or 5/8-inch (16 mm) in alloy steel. Ream the holes 1/16-inch (2 mm) larger. The holes may be drilled from the solid to 1/16- inch (2 mm) larger than the nominal diameter or the bolts.

B. Punched Holes. Make holes, punched full size, 1/16-inch (2 mm) larger than the nominal diameter of the bolt. The die diameter cannot exceed the diameter of the punch by more than 1/16-inch (2 mm).

Ream undersized holes. Clean-cut holes without torn or ragged edges. Poorly matched holes will be rejected.

C. Accuracy of Punched and Sub-drilled Holes. Punch all holes, punched full size, sub-punched, or sub-drilled so that after assembling (before any reaming is done) a cylindrical pin 1/8-inch (3 mm) smaller in diameter than the nominal size of the punched hole will enter without drifting, in at least 75 percent of the contiguous holes in the same plane. Any hole that will not pass a pin 3/16-inch (5 mm) smaller in diameter than the nominal size of the punched hole will be rejected.

D. Reamed or Drilled Holes. Ream or drill all holes, perpendicular to the member, and not to exceed 1/16-inch (2 mm) larger than the nominal diameter of the bolts. Where practical, use mechanically directed reamers.

Drill holes 1/16-inch (2 mm) larger than the nominal diameter of the bolts.

Remove all outside surface burrs. Poorly matched holes will be rejected. Use twist drills for reaming and drilling. Disassemble assembled parts to remove burrs caused by drilling. Assemble connecting parts to be reamed or drilled and held during the work, then match-mark before disassembling.

E. Accuracy of Reamed and Drilled Holes. Eighty-five percent of reamed or drilled holes in any contiguous group must not exceed a 1/32-inch (0.8 mm) offset between adjacent thicknesses of metal.

556.03.9 Bolts and Bolted Connections.

A. General. Make bolted connections meeting the Contract requirements. Use unfinished bolts (ordinary rough or machine bolts). Provide turned bolts when specified. Special ribbed drive-fit bolts may be substituted for turned bolts with the Project Manager's written approval.

Provide bolted connections, using high-tensile-strength bolts, meeting Subsection 556.03.9(E) requirements.

Furnish bolts that are free of rust. Lubricate bolts before use.

Drive the bolts into the holes without damaging the thread. Use snaps to prevent damaging the heads.

Draw the heads and nuts tightly against the work with wrenches. Tap bolt heads with a hammer as the nuts are being tightened.

Use beveled washers to provide full bearing to the head or nut where bolts are used on beveled surfaces.

All bolts threads must be cut and finished.

Fully draw up the nuts of unfinished turned bolts and ribbed bolts after tightening.

Fully erect continuously supported girder sections between expansion joints before production bolt tightening. Tighten field splices to the proof loads in Table 556-5 after field splices have been set to grade.

B. Unfinished Bolts. Furnish standard unfinished bolts having hexagonal heads; with nuts having a bolt hole diameter 1/16-inch (2 mm) larger than the bolt diameter. Use threaded bolts, for transferring shear, to prevent no more than one thread within the grip of the metal. Furnish bolts that extend through the nuts a maximum 1/4-inch (6 mm).

C. Turned Bolts. Ream turned bolt holes, and turn the bolts to a driving fit with the threads entirely outside of the holes. Use hexagonal headed bolts and nuts and provide washers. Turned bolts must be finished cut.

D. Spacing and Edge Distance of Bolts. Follow the spacing and edge distance of bolts specified in Table 556-3.

TABLE 556-3
SPACING AND EDGE DISTANCE OF BOLTS

BOLT LOCATION	BOLT SIZE			
	1" M 24 mm	7/8" M 22 mm	3/4" M 20 mm	5/8" M 16 mm
	Spacing or Distance - Inches			
Minimum Spacing of Bolts Center-to-Center	3½" 90 mm	3" 75 mm	2½" 65 mm	2¼" 55 mm
Minimum Distance From Center of Bolt to Nearest Sheared Edge and to Edges of Beams and Channels	1¾" 45 mm	1½" 40 mm	1¼" 30 mm	1⅛" 25 mm
Minimum Distance From Center of Bolt to Nearest Rolled or Planed Edge	1½" 40 mm	1¼" 30 mm	1⅛" 25 mm	1" 25 mm
Maximum Distance From Center of Bolt to Nearest Edge	Eight times the thickness of the thinnest outside plate but not greater than 5" (125 mm) for all bolt sizes			

E. Bolted Connections - High-Tensile-Strength Bolts.

1. **Bolt Lengths.** Use bolt lengths having the grip-length values in Table 556-4 plus the total thickness of connected material. The values in Table 556-4 consider nut, one flat washer, and bolt point.

Adjust the length to the next 1/4-inch (10 mm) increment up to a 5-inch (120 mm) bolt and to the next ½-inch (10 mm) increment for bolts over 5-inches (120 mm).

Increase the bolt length ⅛-inch (3.2 mm) if direct tension indicator washers are used.

TABLE 556-4
BOLT LENGTH DETERMINATION

BOLT DIAMETER	ADDED GRIP LENGTH*
½" (13 mm)	7/8" (22 mm)
5/8" (16 mm)	1" (25 mm)
3/4" (19 mm)	1⅛" (29 mm)
7/8" (22 mm)	1⅜" (35 mm)
1" (25 mm)	1½" (38 mm)
1⅛" (29mm)	1⅝" (41 mm)
1¼" (32 mm)	1¾" (44 mm)

*To be added to total thickness of connected material.

TABLE 556-4 METRIC
BOLT LENGTH DETERMINATION

BOLT DIAMETER	ADDED GRIP LENGTH
M16 mm	25 mm
M20 mm	30 mm
M22 mm	35 mm
M24 mm	40 mm

Where beveled washers are used, adjust bolt lengths to account for the use of nonstandard or beveled washers.

2. **Bolted Parts.** Assure bolted surfaces in contact with the bolt head and nut do not have a slope of more than 1:20 to a plane normal to the bolt axis.

   Assure bolted parts fit solidly when assembled without gaskets or other compressible material.

   Remove all mill scale, dirt, burrs, and other defects that prevent solid seating of the parts.

   Clean contact surfaces of oil, paint, lacquer, or galvanizing.

3. **Installation.** Install bolts with a hardened washer under the nut or bolt head, whichever element is turned in tightening. Use a hardened washer under the head of regular, semi-finished hexagon bolts and under finished hexagon nuts, even when these are not the elements turned in tightening. Washers may be omitted under the head of heavy hexagon bolts and interference-body bolts and under heavy, semifinished hexagon nuts, when these are not turned. A flat washer

may be used when the surface adjacent to the bolt head or nut does not have a slope greater than 1:20 to a plane normal to the bolt axis. Use a smooth beveled washer where the outer face of the bolted parts has a slope greater than 1:20 to a plane normal to the bolt axis.

Tighten each fastener to provide the minimum tension in Table 556-5 when all fasteners in the joint are tight.

Tighten threaded bolts as specified in Subsections 556.03.9(E)(3)(a) or (b). Turn the bolt if the nut is prevented from rotating because of clearance problems.

TABLE 556-5
FASTENER TENSION

BOLT SIZE INCHES (mm)		*MINIMUM FASTENER TENSION POUNDS (A 325 BOLTS) (kN)	
1/2	(13 mm)	12,050	(53.5 kN)
5/8	(16 mm)	19,200	(85.3 kN)
3/4	(19 mm)	28,400	(126.2 kN)
7/8	(22 mm)	39,250	(174.4 kN)
1	(25 mm)	51,500	(228.9 kN)
1-1/8	(29 mm)	56,450	(250.9 kN)
1-1/4	(32 mm)	71,700	(318.7 kN)
1-3/8	(35 mm)	85,450	(379.8 kN)
1-1/2	(38 mm)	104,000	(462.2 kN)

* Equal to 70 percent of specified minimum tensile strengths of bolts.

TABLE 556-5 METRIC
FASTENER TENSION

BOLT SIZE (mm)	MINIMUM FASTENER TENSION
M 16 mm	94.2 kN
M 20 mm	147 kN
M 22 mm	182 kN
M 24 mm	212 kN

Impact wrenches perform the required tightening of each bolt in approximately ten seconds.

a. Turn-of-Nut Tightening. Bring a minimum 50% of the bolts up snug tight. Then bring the remaining bolts up snug tight. Then tighten all bolts starting with the inside bolts working towards the free edge under Table 556-6. Permit only the element being tightened to turn. Obtain the Project Manager's approval of the tightening method.

TABLE 556-6
NUT ROTATION FROM SNUG TIGHT CONDITION

Bolt length (as measured from underside of head to extreme end of point	DISPOSITION OF OUTER FACES OF BOLTED PARTS		
	Both faces normal to bolt axis	One Face normal to bolt axis and other face sloped not more than 1:20 (bevel washers not used	Both faces sloped not more than 1:20 from normal to bolt axis (bevel washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12	2/3 turn	5/6 turn	1 turn

Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. For bolts tightened by one-half turn and less, the tolerance is plus or minus 30° (1/12 turn); for bolts tightened by two-thirds turn or more, the tolerance is plus or minus 45° (1/8 turn).

The rotation for bolts exceeding twelve diameters is by testing representative bolts in a tension device.

b. Calibrated Wrench Tightening. Provide bolt tension at least 5% more than the tension specified using calibrated wrenches. Calibrate wrenches at least once each working day for each bolt diameter installed. Re-calibrate wrenches when equipment changes or when differences in the surface condition of the bolts, nuts, or washers is observed. Calibrate by tightening 3 bolts of each diameter, in a Skidmore-Wilhelm calibrator or approved equal.

Adjust the wrenches to prevent nut or bolt rotation from exceeding that specified in Table 556-6. Tighten the nuts to the specified torque when using manual torque wrenches.

When using calibrated torque wrenches to install bolts in one joint, check the bolts with the wrench after initial tightening of all bolts.

Adjust power wrenches to stall or cut out at the required tension.

4. **Inspection.** The bolt installation will be inspected to verify procedures and results.

Bolt tension is checked in each connection by applying the job inspection torque to at least 10% of the bolts, but not less than 2. If any element is below the job inspection torque, re-torque all bolts in the connection. Tighten and re-inspect any element turned by the job inspecting torque. As an alternate, the Contractor may re-tighten all bolts in the connection and request a re-inspection of the connection.

Assist the inspector with bolt tension checks. Provide an approved torque wrench as the inspection wrench. The Inspector will observe the wrench readout as the bolt is being checked.

The job inspection torque is established from 3 bolts of the same grade, size, and condition as those in the work. The bolt length may be any length representing bolt lengths used in the structure. A new inspecting torque is established when the bolt grade, size, or condition changes. Place the bolts in an approved calibration device that will indicate bolt tension. Use the same surface under the nut and bolt for testing as that used in the structure when establishing the inspection torque.

Bring the 3 bolts to an initial tension of approximately 15% of the fastener tension in Table 556-5, then tighten to the minimum tension in Table 556-5. Tightening above the initial tension must not cause nut rotation beyond that permitted in Table 556-6. Turn the turned element 5° (approximately 1-inch (25 mm) at a 12-inch (300 mm) radius and read the applied torque. The average of the torque readings in the 3 tests is the job inspection torque.

556.03.10 Welding Requirements. Meet the current requirements of the American National Standard Bridge Welding Code, ANSI, AASHTO, the AWS Structural Welding Code, and the Contract. Use AWS certified welders for the type of weld required.

556.03.11 Welded Stud Shear Connectors. The type, size or diameter, and length of stud shear connectors are specified in the Contract.

Furnish fabrication material and perform welding meeting Subsection 556.03.10 requirements.

556.03.12 Field Welding. Do not weld temporary construction supports to beams, girders, or other main members. Unauthorized field welds, tack welds, or arc strikes to any member will be rejected.

556.03.13 Assembling Steel. Field or shop assemble steel parts as follows:

A. **Shop Work.** Clean all contacting metal surfaces of deleterious materials before assembling, bolting, or welding. Paint may be applied to contact surfaces after bolting or welding.

Shop assemble and adjust to line and camber all bolted trusses, continuous plate girders, curved steel elements, box girders, I-beam spans, skew portals, skew connections, rigid frames, bents, and towers.

Drill and ream the field splice holes during assembly. Holes for other field connections may be shop drilled or reamed with the connecting parts assembled or drilled or reamed to metal templates with hardened bushings, without assembling.

Use an approved alternate procedure where shop space prevents complete shop assembly of continuous span girders or trusses. The procedure may require adjusting the line and camber of at least two abutting sections of girder for drilling or reaming of field splices if all girder lines for the complete structure are assembled consecutively.

Field butt joints for welded girders may be assembled with abutting members adjusted for line and camber and prepared to fit for welding, subject to Project Manager approval.

Bridge expansion devices must be initially shop assembled to establish the proper fit between the joint parts.

B. Field Work. Assemble the parts as specified in the Contract, following the match-marks. Prevent damaging the material while handling. Clean bearing surfaces and all member surfaces in permanent contact before assembly.

Splices and field connections must have a minimum of one-half of the holes filled with bolts or erection pins before removing temporary supports or releasing the load from erecting equipment. Splices and connections carrying traffic during erection must have three-fourths of the holes pinned or bolted.

Do not begin production bolt tightening of the field splice bolts until the complete girder line is aligned and erected matching the full camber line.

Use erection pins 1/32-inch (1 mm) larger than the nominal diameter of the permanent bolts.

Erect truss spans on blocking, unless they are erected using the cantilever method, to provide truss camber. Leave the blocking in place until the tension cord splices are fully bolted and all other truss connections pinned and bolted. Do not tension bolts in butt joint splices of compression members and in railings until the span is swung.

C. Drifting of Holes. Only use drift pins during assembly to the extent necessary to bring the parts into position without enlarging or distorting the holes or metal. Enlarge holes by reaming to fit the bolts.

D. Match-marking. Match-mark parts assembled in the shop for reaming field connection holes and furnish the Project Manager a diagram showing the marks.

556.03.14 Marking and Shipping. Paint or mark each member with an erection mark, and furnish the Project Manager an erection diagram detailing the erection marks.

Furnish the Project Manager copies of material orders, shipping statements, and erection diagrams. Show the individual member weights on the statements.

A shipping statement must accompany the material and be marked to clearly identify it with the delivered material and mill test reports.

Mark the weight on members weighing 3 tons (2.7 mt) or more. Load and unload structural members on trucks or cars without stressing or causing damage.

Pack bolts, loose nuts or washers of each size separately. Ship pins, small parts, bolts, washers, and nuts in boxes, crates, kegs, or barrels, with the gross weight of each package not exceeding 300 pounds (136 kg). Plainly mark each shipping container, listing and describing the contents on the outside of each shipping container.

Keep structural material clean and free from damage.

556.03.15 Painting. Clean and paint all iron and steel surfaces meeting Section 612 requirements.

556.03.16 Erection. Erect the members using the camber diagrams on the drawings and complete the structure or structures as specified.

When requested, furnish the Project Manager erection details before starting the work.

Support girders and beams at intervals that maintain camber, elevation, and horizontal alignment during final grading, bolt-up, and field splice tightening.

556.03.17 Handling and Storing Materials. Store materials off the ground and keep them clean and dry. Place and shore girders and beams upright. Support long members, including but not limited to columns, chords, and girders, on blocks spaced to prevent deflection. For erection contracts, check the material received against the shipping lists and report in writing all shortages and damaged materials. Be responsible for lost or damaged material while in Contractor possession.

556.03.18 Falsework. Design, construct, and maintain falsework to support the maximum construction loadings. Check and approve falsework drawings and submit them to the Project Manager. The Department has 20 working days for review. Delays beyond this time will extend the contract time day for day for the number of working days beyond the 20 days.

556.03.19 Bearing and Anchorage. Place masonry bearing plates on bearing areas that meet specifications. Install bearing plates level to provide an even bearing on the masonry.

Place masonry bearing plates on fiber-reinforced pads, that project a minimum of ½-inch (13 mm) on all sides of the bearing plates.

Make allowances for bottom chord elongation due to dead load when setting shoes or bearing plates for steel truss spans.

Install bridge rocker shoes to be vertical under full dead load at 60 °F (15 °C). Raise spans and make adjustments if the rockers are not correctly positioned with the final dead load on spans.

Construct concrete surfaces receiving elastomeric pads to compensate for bearing pad compression. Finish the bearing area with a wood float to a level plane. The surface must not vary by more than 1/16-inch (2 mm) from a straightedge placed in any direction across the area. Extend the bearing area at

least 1-inch (25 mm) beyond the elastomeric bearing pad dimensions. The finished elevation of the bearing surface must not vary by more than 1/8-inch (3 mm) from the specified beam-seat elevation unless otherwise approved.

556.03.20 Placing Anchor Bolts. Place anchor bolts meeting Subsection 552.03.14 requirements.

556.03.21 Straightening Bent Material. Straighten bent plates, angles or other shapes without damaging the material. The metal may be heated if approved. Do not exceed 1000 °F (537 °C). Once heated, cool the metal slowly.

All straightened metal will be inspected for defects.

556.03.22 Pin Connections. Furnish the Project Manager the pilot and driving nuts provided with the steelwork once the work is complete. The members must take full bearing on the pins. Bring pin nuts up tight, and burr the threads at the nut face.

556.03.23 Misfits. Correct all misfits, errors, and injuries as a part of the assembly and erection work. Report to the Project Manager all shop work errors that prevent the assembly and fitting of parts with a minimum use of drift pins, reaming, slight chipping or cutting. Obtain Department approval for the correction method. Corrections must be inspected and approved.

556.03.24 Cleanup. Remove all falsework, excavated or unused materials, rubbish, and temporary buildings. Restore all public and private property damaged during construction to its original condition.

Pull, cut off or otherwise remove all falsework piling 1 foot (305 mm) below finished the ground line or streambed, unless otherwise directed. Perform all work affecting the stream channel meeting the applicable requirements of Subsection 208.03.4 before final acceptance.

556.03.25 Rejections. An inspectors acceptance of material or finished members does not prevent later rejection if defects are found. Replace or repair rejected material and work at Contractor expense.

556.04 METHOD OF MEASUREMENT.

556.04.1 Lump Sum Basis. No measurement of structural steel quantities is made.

556.05 BASIS OF PAYMENT. Payment for the completed and accepted quantities is made under the following:

Pay Item	Pay Unit
Structural Steel	Lump Sum

The weight of structural steel in the Contract is an estimate only. No guarantee is made that the estimated weight is the correct weight to be furnished. No adjustment in the contract price is made if the weight furnished is more or less than the estimated weight.

If changes in the work ordered by the Project Manager vary the weight of steel to be furnished, the lump sum payment is adjusted as follows:

The value per pound (kilogram) of a decrease or increase in the weight of structural steel involved is determined by the following:

$$\textbf{Value per pound (kilogram)} = \frac{\textbf{Contract Lump Sum Bid}}{\textbf{Estimated Contract Weight}}$$

The adjusted contract lump sum amount paid is the contract lump sum bid plus or minus the value of steel involved in the change.

Should the ordered change materially alter the character of the work and the unit cost, compensation for that work is made at an agreed price established before the work is performed. Detail, in writing, the changes in procedures and the resulting costs for labor, equipment, and materials to support the agreed price.

The following percentages of the total quantity of structural steel in place are allowed for payment on progress estimates:

1. 90 percent when erected;
2. 97 percent when bolted and spot painted;
3. 100 percent when painted in compliance with the plans and specifications.

Payment at the Contract unit price is full compensation for all resources necessary to complete the item of work under the Contract.

SECTION 557
STEEL BRIDGE RAILING

557.01 DESCRIPTION. This work is the furnishing and installing of steel bridge railing.

557.02 MATERIALS. Furnish materials meeting the following Subsection requirements:

Structural Steel Tubing	711.03
High Tensile Strength Anchor Bolts	711.06
Galvanized Metal	711.08
Structural Steel	711.02
Steel Beam Guardrail and Wood Blocks	705.01
Fiber-Reinforced Pads for Rail Post Base Plates	711.16

557.03 CONSTRUCTION REQUIREMENTS.

557.03.1 Fabrication Drawings. Furnish fabrication drawings for steel bridge railing meeting Subsection 556.03.2 requirements.

557.03.2 Fabrication. Fabricate steel bridge railing meeting the applicable requirements of Section 556.

557.03.3 Erection. Construct steel bridge railing as shown on the plans. Adjust the completed railing to compensate for any unevenness in the structure. Assure all rail posts are vertical. Do not place railing on a span until centering or falsework is removed. Place rail post base plates on fiber-reinforced pads, sized and positioned to project a minimum ½-inch (13 mm) on all sides of the base plates.

557.03.4 Painting. Clean and paint steel bridge railing specified to be painted meeting Section 612 requirements.

557.04 METHOD OF MEASUREMENT. Steel bridge railing of the type or types specified are measured by the linear foot (meter). Measurement is based on the computed horizontal distance between the centerlines of end base plates.

557.05 BASIS OF PAYMENT. Payment for the completed and accepted quantities is made under the following:

Pay Item	Pay Unit
Bridge Railing	Linear Foot (linear meter)

The following percentages of the total linear feet (meter) of steel bridge railing in place are allowed for payment on progress estimates:

1. 90 percent when erected;
2. 95 percent when bolted and spot painted;
3. 100 percent when painted in compliance with the Contract.

Payment at the contract unit price is full compensation for all resources necessary to complete the item of work under the Contract.